A REVIEW OF THE STUDY AND TREATMENT OF HEATSTROKE AT THE PENNSYLVANIA HOSPITAL AND ELSEWHERE, 1751-1870.[1]

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Knowledge of the pathological effects of heat and of its literature has been acquired by most authors on these topics, in the reverse of the ideal order.

Unexpected experience has incited study that should have been preparatory. Such study has almost invariably resulted in the expression of two regrets—one, that so little was written; the other, that there was yet so much to know.

A liberal experience in 1892, the availability of case statistics dating from 1751, of meteorological data from 1831 and of case histories from 1873, at the Pennsylvania Hospital, all prompted not only their study, but also that of collateral publications. This reading betrayed that many authors wrote in ignorance of the work of their predecessors and of their contemporaries. Therefore the erroneous belief "that so little was written" justly gave way to regret that much which was written was so little known. This fact, and the completion by the Pennsylvania Hospital of its first century and a half of medical record, prompts the writing of this review and the publication, at a later date, of supplementary papers dealing either with other periods or branches of this topic.

The aim of this contribution has been to present for convenient reference, in chronological order, the observations, thoughts, and often the words of workers in this field during the period named.

INTRODUCTORY.

Biblical references[2] to fatality following exposure to the sun are followed after the lapse of centuries by the observations of Forestus,[3] in 1562, of Baglivi, in 1694, and of Lancisi, in 1705.[4] These three observers confounded the effects of heat with the symptoms of apoplexy, and this confusion was perpetuated by some observers up to 1852.

Forestus recommended, in the treatment of this condition, stimulating frictions, and observed that in many instances blood-letting was unnecessary. He was the first to distinguish two types of cases, the mild and the fatal. Baglivi and Lancisi also recognized the predisposing influences of heat and humidity, and added that the depressing influences of prevalent war were contributory. On July 8, 1707, many people and animals were reported by Mosely[1] to have died in England from the heat of the sun. In 1738, in the early part of August, as reported by Dr. Lining,[2] the thermometer in the shade at Charleston, S. C., rose successively for some days to 98° F., and "several persons died of apoplexies." In 1743, from July 14th to 25th, 1100 people are reported by this authority to have perished in the streets of Pekin from the same cause.

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[1] Read in outline before the College of Physicians, June 1, 1901.

[2] J. J. Levick. The American Journal of the Medical Sciences, 1859, vol. xxxvii. p. 40.

[3] Loc. cit., p. 49.

[4] Loc. cit., p. 48.

PERIODS I. AND II.—1751-1810.

Diagnoses of Apoplexy, Effects of Drinking Cold Water, and Coup de Soleil Confounded.

In 1769, eighteen years after the founding of the Pennsylvania Hospital, its records show the first entry of the pathological effects of atmospheric heat—under the diagnosis of "hurt by drinking cold water." This case was that of a woman who spent two days in the hospital. Fifteen similar entries with such variations in phrasing as "convulsions" or "inflammation of stomach from drinking cold water," making a total of 16 cases and of 3 deaths, the first of which is recorded on the 31st day of the 8th month, 1793 (see Graphic and Statistical Chart in later publication), are entered on the hospital register prior to 1831, when the phrases "Effects of Heat" (May 1, 1831) and *coup de soleil* (June 1, 1831) appear for the first time, showing an advance in the etiological appreciation of this condition. The last entry of "drinking cold water" is made on June 10, 1838.

The diagnoses having in common a reference to "cold water" were, doubtless, made or directed by subscribers to the popularly accepted teaching on the subject by Dr. Benjamin Rush, who, however, was not associated with the hospital as one of its visiting physicians at the time of the first cold-water diagnosis noted—1769—but became so, fourteen years later, on May 26, 1773, and so continued until his death April 19, 1813.

In 1789 Dr. Benjamin Rush[3] published in *London* his *Medical Inquiries and Observations*, one of which is entitled *An Account of the Disorder Occasioned by Drinking Cold Water in Warm Weather, and the Method of Curing It.*

It had been noted by Dr. Rush that in some summers four or five persons, usually laborers, died suddenly in one day subsequent to drinking pump water. The following paragraphs present the pith of his observations:

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[1] Mosely. Tropical Diseases, London, 1803, p. 57.

[2] Dickson. Observations on the Effects of Heat. THE AMERICAN JOURNAL OF THE MEDICAL SCIENCES, 1828, vol. iii. p. 268.

[3] Rush. Medical Inquiries and Observations, 2d edition, Philadelphia, 1789, p. 150.

"Three circumstances generally concur to produce disease or death from drinking cold water: 1. The patient is extremely warm. 2. The water is extremely cold. 3. A large quantity of it is suddenly taken into the body." The danger is in proportion to the degree of combination of the three circumstances cited.

"In a few minutes after the patient has swallowed the water he is affected by a dimness of sight; he staggers in attempting to walk, and unless supported, falls to the ground; his nostrils and cheeks expand and contract in every respiration; his face appears suffused with blood, and of a livid color; his extremities become cold, and his pulse imperceptible; and unless relief is speedily obtained the disorder terminates in death in four or five minutes.

"*I know* of but one certain remedy for this disease, and that is *liquid laudanum.* The doses of it, as in other cases of spasm, should be proportioned to the violence of the disease. From a teaspoonful to near a tablespoonful have been given in some instances before relief has been obtained."

Patients were directed—

"1. To grasp the vessel out of which they are about to drink for a minute or longer with both hands; that a portion of heat may be abstracted from the body and imparted to the cold liquid.

"2. If they are not furnished with a vessel to drink out of, but obliged to drink at a pump or spring, always to wash their hands and face, previous to drinking, with a little of the cold water. By receiving the shock of the water first on those parts of the body, a portion of its heat is conveyed away, and the vital parts are defended from the action of cold."

The *theory* presented and the *treatment* advised by Dr. Rush in relation to the observations quoted was subscribed to by partisans and controverted by opponents, who also contended much among themselves, and who—with their posterity—may be roughly classed as follows:

I. Those who, like Dr. Rush, failed to distinguish the effects of heat and those of all kinds of *immoderate drinking.*

This class may be thus subdivided:

1. Those who agreed with Dr. Rush's theory and treatment of the effects of cold drinks upon overheated and exhausted persons.

2. Those who differed with Dr. Rush upon these topics.

II. Those who contended that the "disorder" described by Dr. Rush was due to *the effects of heat,* of which thirst and drinking is a symptom and not a cause.

This class contains vitally differing beliefs:

1. Those who held that heat effects were always *congestive*, that they frequently resulted in apoplexy and that the condition must always be met by depletion. This is the earliest teaching in this matter, and it had its supporters as late as 1856.

2. Those who deemed heat effects to invariably result in *exhaustion* demanding routine application of heat, administration of stimulants, and without exception contraindicating blood-letting.

3. Those who saw that heat effect and apoplexy were diseases apart, and also that heat caused at least two widely differing conditions:

a. Febrile or congestive, demanding the application of cold and sometimes benefited by depletion.

b. Exhaustion—indicating rest, sometimes stimulants and artificial heat, and always contraindicating blood-letting.

This classification represents the principal differences of opinion that have obtained at various periods down to the present day; it necessarily fails to take account of several composite beliefs, and contains many subdivisions. Each subdivision of Class II. may again be subdivided, according as its exponents thought that direct *solar* heat, or knew that its indirect form and that *artificial* as well as solar heat, would produce the results observed.

In 1798 Dr. James Currie[1] published in his *Medical Reports on the Effects of Water* a chapter entitled "On the Disease that Arises from Drinking Cold Liquid, or Using the Cold Bath after Severe Exercising." Like Dr. Rush, he failed to note that the accompanying atmospheric heat, in the majority of the cases cited, was the exciting and not, as they supposed, merely a predisposing cause. He otherwise elaborately differed from Dr. Rush. According to Dr. Currie's theory of the fatal phenomena reported, the latter occurred not because the individuals drinking were overheated, but because they had been overheated. They had, he supposed, paused after their exhausting exertions, had begun to chill by perspiration, were in a condition of depression fatally increased by the draught of cold water—that could have been taken with impunity in the heat of exercise. He, therefore, considers the precautionary suggestions of Rush—because of their nature chilling—as contributory to and not preventive of evil. That this scholarly physician in Liverpool should at that period fail, in reading, to detect symptoms incident to torrid temperature outside of his experience, is hardly surprising. There were, however, those who, with advantages of observation, correctly divined heat to be the cause of the supposed *cold* water malady, and classified its manifestations.

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[1] Medical Reports on the Effects of Water, Cold and Warm, as a Remedy in Fever and Other Diseases, Whether Applied to the Surface of the Body or Used Internally, Including an Inquiry into the Circumstances that Render Cold Drink or the Cold Bath Dangerous to Health, etc. James Currie, M.D., F.R.S., Liverpool, 1798, p. 95.

Period III.—1811-1841.

Supposed Cold Water Effects Recognized as Coup de Soleil, Which Is Still Confounded with Apoplexy.

In 1811 Hillary's[1] work on *Tropical Diseases* appeared, with notes by Benjamin Rush. It states that upon the change of the weather from very dry and warm to very moist and warm "dysenteries became very frequent;" "and some were seized with apoplexies and palsies, and some of the first died before any proper assistance could be called in." In a foot-note he queries: "Were not the apoplexies and palsies also produced by the same causes, viz., a diminution or stoppage of the perspiration?" etc. This report is replete with meteorological data; but some of the cases referred to evidently resulted from heat and humidity, and not from apoplexy.

In 1814 Dr. Benjamin H. Coates "inhabited the Pennsylvania Hospital," as he reported in 1858, in his discussion[2] of Dr. Levick's "Remarks on Exhaustion from Heat (Sunstroke)," before the College of Physicians. He recalled that at this time, by order of the Humane Society, the public pumps were posted with cautions against sudden death from drinking cold water. He saw many persons at the hospital (Pennsylvania) alleged to be suffering from a spasmodic affection of the stomach, described by Dr. Rush as a result of drinking cold water; but it was Dr. Coates' opinion, and that of some medical attendants at the hospital, that these patients were usually under the influence of ardent spirits and suffered rather from congestion of the brain than that of the stomach.

Speaking of the cases in 1814, Dr. Coates goes on to say: "The cephalic cases received little other treatment than rest, silence, a gloomy room, *cold to the head*, mild stimulants to remote parts of the skin, laxatives, and a cool abstemious and sedative diet." This is the earliest mention found of the use of cold in these cases. He comments that the great terror of the destructive effects of the use of ice in drinks, etc., and its apparent dangers were then (1858) forgotten. He had not examined the hospital records, but had no recollection of any death in such cases at that period, 1814. The hospital records are confirmatory (see chart in later statistical publication). The cases could not have been of grave character.

In the winter of 1818, Dr. D. Francis Condie, as he reported in 1850 to the College of Physicians, in his discussion of Dr. Pepper's communication on "Coup de Soleil," attended a "colored preacher" seized in the midst of his exhortation, in a crowded and overheated church, by convulsions alternating with tremors. Dilated pupils, thready pulse, and clammy surface were accompanying conditions. He says: "In this case the disease was produced by the exhausting effects of undue exertion in a heated and confined atmosphere; and he believed that in those who are attacked while laboring in the open air, during the intense heat of summer, it is also produced by exhaustion, and not by any direct influence of the sun's rays, as some have supposed." Dr. Condie's narration of this case and his comments upon it place him not only as the first to distinguish between congestion and exhaustion from heat, but also as the first to recognize that heat alone was the essential cause of the phenomena the which for many years later were attributed to the sun alone. In this regard it is interesting to refer to Dowler's explicit and contrary statement in 1841 (p. 496 of this review), also that Dr. Geddes'[1] ("Clinical Observations on Diseases of India, 1846") relates a case of heat effect occurring in a convalescent from measles, who was in hospital and not exposed to the sun.

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[1] William Hillary. Observations on the Changes of the Air and the Concomitant Epidemical Diseases in the Island of Barbadoes, etc., 2d edition, London, 1776, p. 18, with notes by Benjamin Rush, Philadelphia, 1811.

[2] Transactions of the College of Physicians of Philadelphia, 1858, n. s., vol. iii, p. 235.

In 1818 Dr. John Watts, Jr.,[2] submitted to the Medical Society of the County of New York, "Remarks on the Supposed Effects of Drinking Cold Water; Illustrated by Cases which Occurred During the Hot Weather of the Summer of 1818."

This paper is of peculiar interest, as the first published protest against attributing to water the effects of heat. The reminiscences of Dr. Coates referring to 1814 were not recorded until 1858. The theory voiced by Rush was popularly accepted. This initiatory attack, though not without fault, was well prepared and pushed far, but it took many others to eradicate an error which was last defended in 1859.

The author most ably and fairly reviews and discusses the cold water controversy, quoting Rush,[3] Currie,[4] and Jackson.[5] He takes ground: that the "usual effects" of intemperate water drinking are not denied, nor altogether its agency in producing the symptoms noted; that an "ardent sun" independent of water drinking is in itself sufficient to cause "*coup de soleil*, or sunstroke;" that the symptoms of the latter are "analogous" to those attributed that summer to the effects of cold water; that the contention of the author had the support of reputable physicians who characterized patients suffering from this disease as "rum and sun cases;" that although the disorder described by Rush terminates by "death in four or five minutes," yet no "sudden death" had been heard of from this cause; that laudanum was not, in this regard, a specific remedy, since no recovery was attributed to its sole influence, whereas, many cures were noted in sequence to copious bleeding; finally, that there was reason to fear that some persons fell "victims to the injudicious and extravagant administration of laudanum." The abuse of opium at this time in the treatment of heat or cold water effects was probably the cause of this helpful remedy falling into disfavor until reintroduced in 1868 by Drs. Hutchinson and Norris (p. 520 of this review).

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[1] Wood. Sunstroke, Philadelphia, 1872, p. 10.

[2] John Watts, Jr. The Medical and Surgical Register, New York, 1818, p. 81.

[3] Rush. Loc. cit. [4] Currie. Loc. cit. [5] Jackson on Cold Water, p. 377.

The symptoms he cited of the group of 13 cases reported are typical of the major form of heat effect. It is of interest to note that: "The heat of the body was likewise remarkably great, and in some instances continued for a long time after bleeding."

Two of the 13 cases reported, died; but one was examined by autopsy, and it exhibited "about five ounces of extravasated blood on the surface of the dura mater." This case, apparently of true apoplexy, naturally confirmed Dr. Watts in his prejudice that the pathological result of heat effect was apoplexy.

The scheme of treatment included: "laudanum, æther, and other stimulants," "when the apoplectic symptoms had not yet supervened," the influence of these agents was but "momentary," apoplectic symptoms developing in a short time; the rubbing of aqua ammonia over the whole body, a measure credited with lessening the bodily heat as well as arousing the patient from an apparently fatal torpor; and, finally, large and repeated bleedings. It was upon blood-letting that Watt placed most reliance. Several of his patients were bled of sixty, and one of eighty ounces in two hours.

As he inveighed against overdosage with laudanum, so did those following him unsparingly condemn routine and reckless blood-letting.

In 1821 the British frigate "Liverpool,"[1] when in the Persian Gulf, lost "from a species of *Coup de Soleil,*" three lieutenants and thirty men in one day, although double awnings were stretched and the decks kept wet.

In 1824, as reported by Dr. Samuel H. Dickson[2] in 1828, nine consecutive days on which the temperature was 90° F. or above, preceded by six days in which the temperature was 90° F. or near it, resulted in 34 deaths from "apoplexy and insolation" in Charleston, S. C.

In 1826 Dr. Daniel J. Carroll,[3] presented his "Observations on the Morbid Effects Produced by Drinking Cold Water." This article, in spite of the contrary desire announced in the introduction, admirably presents the confusion of ideas prevalent upon the effects of heat at this time. It begins as follows:

"Notwithstanding the number who are supposed annually to perish from this cause (referring to the title), yet there are many cases which result from heat alone, or exposure to the direct rays of the sun, producing the *coup de soleil* of the French. Other forms of cerebral affection, from simple congestion of the brain to apoplexy (though as discordant with this, in their nature as mode of cure), have, nevertheless, been erroneously attributed to cold water," etc.

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[1] Wellsted's Travels to the City of Caliphs.

[2] Dickson. THE AMERICAN JOURNAL OF THE MEDICAL SCIENCES, 1828, vol. iii. p. 271.

[3] Carroll Philadelphia Journal of the Medical and Physical Sciences, 1826, vol. xiii. p. 122.

In spite of the avowed intention of the paper to distinguish heat from cold water effects, it details with evidences of much unconsciousness and erudition undoubted cases of sunstroke as due to cold water drinking. An interesting feature of the symptomatology is the mention of a vesicular eruption. Like Watt, he comments upon much fatality resulting in mild cases from overdosing with laudanum."

In 1828 Dr. Samuel H. Dickson[1] varied the monotony of title favored by foregoing authors on this topic by publishing the first paper avowedly dealing with "Observations on the Effects of Heat." Reference to the experimental endurance of extraordinary temperature without evil effect is followed, first, by a study of the phenomena and treatment of the condition now popularly known as spring fever, and second, by a report of the cases of insolation and *coup de soleil* from the persistently hot weather in 1824 already noted. His tribute to the cold water theorists is to advise the drinking of cold water in hot weather.

Without having witnessed post-mortem section of a case of heat effect, he concludes the condition to be one of venous engorgement tending to apoplexy. He divides the cases he reports into two classes, the apoplectic or cerebral, and the phrenetic or meningeal. He cites in confutation of Rush a case of apoplexy supposed to be produced by heat, a mulatto with subsequent hemiplegia, who immediately preceding his attack drank water the temperature of which Dr. Dickson found to be about the same as that of the patient. The inference being—that thirst is a symptom marking the onset of the attack. As the water was not cold, it could not, as supposed by the bystanders, have excited an attack of the disorder described by Rush. The coincidence of this case occurring on a warm day in a man laboring in the sun was apparently confirmatory of the theory that heat is productive of apoplexy. On the other hand, cerebral hemorrhage has not been observed at autopsy in cases of heat effect, and the latter most rarely results in hemiplegia.

The cases described as apoplectic were bled, and those classed as meningitic were treated by cold affusions poured from a height on the head of the patient, who was raised to a sitting posture. The return of symptoms calling for a repetition of the affusion is the first record found of what still proves a valuable aid in treatment. The author saw "in one day five persons, three of whom recovered entirely under this simple means of cure." If the recovery was not thus complete, and mania and phrenitis supervened, the cases were for the most part manageable, but now a free use of the lancet became necessary, and purgatives of the *most active* power were demanded.

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[1] Dickson. Observations on the Effects of Heat. THE AMERICAN JOURNAL OF THE MEDICAL SCIENCES, 1828, vol. iii. p. 268.

In 1830 Dr. William W. Gerhard,[1] later a visiting physician to the hospital, was the first to record negative post-mortem appearances of the brain in cases that had died from the effects of heat. His observations are thus presented:

"Symptoms of the same character occur from the effects of heat upon the nervous system during the warm season. During the intensely hot weather of the summer of 1830 I witnessed the opening of the bodies of twenty or thirty persons who died from this cause. We found no organic disease of the brain, but merely a slight congestion—such as is observed in other acute diseases—*which it would be idle to set down as a cause of death.* These were the appearances in those only who died suddenly of exposure to heat; for if time elapses for reaction to come on, inflammation of the brain may take place, but it is then a secondary affection."

In 1830 *The Boston Medical and Surgical Journal,*[2] No. 17, June 8th, reprints the paper of Dr. Rush already quoted (p. 486), and in No. 18, on June 15th—the next issue—publishes a protest to the theory of Rush by Dr. F. J. Higginson, who supports the views of Currie,

In 1831 meteorological observations were begun at the Pennsylvania Hospital, and they continue to the present day. The Government Weather Bureau was not established until many years after that of the hospital. The relation of atmospheric temperature to the occurrence of illness from heat will be considered in a later and statistical publication on this topic. It is of interest to note that the institution of atmospheric observations at the hospital, in 1831, is coincident with its first recorded diagnosis of "Effects of Heat" and *coup de soleil,* such cases prior to that time being attributed to the effects of "drinking cold water."

In 1831 Andral,[3] of Paris, under the classification of "The Eighth Form of Cerebral Congestion," notes a definite thermometric relation between high atmospheric temperatures and the occurrence of symptoms that he classes with cerebral congestion and apoplexy. He reports a number of cases, without fatality, occurring in young soldiers and treated at La Pitié. He also described the post-mortem conditions in two of three undoubted sunstroke cases, and noted in both of them petechiæ, liquid blood, pulmonary, cerebral, and venous engorgement, and in one of them that had *contracted heart*, which later was observed experimentally by Bernard, in 1859, and by Wood at autopsy, in 1863. No cerebral or meningitic effusions were discovered.

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[1] Graves' System of Clinical Medicine, with Additional Lectures by William Gerhard, Philadelphia, 1848, p. 677.

[2] Boston Medical and Surgical Journal, 1830, vol. iii. p. 265.

[3] G. Andral. Medical Clinic, or Reports of Medical Cases. Translated by D. Spillan, Philadelphia, 1838, p. 108.

In 1836 the first English report of congestion of the lung as a post-mortem observation, in 1834, in the cases of three soldiers, was made by J. J. Russell,[1] of the Seventy-third Regiment, English Army. He was surprised to find no congestion of the brain. It must be remembered that even up to 1856 the effects of heat were confounded with apoplexy.

The exciting cause was exposure to the sun at the funeral of a general officer at Madras, India; the predisposing causes were red coats and military stocks. Some eighteen men were overcome. Three died promptly where they fell, and two others some hours later. In the fatal cases the symptoms and post-mortem appearances were alike. The symptoms reported were "*excessive thirst*, and a sense of faintness; difficulty of breathing, stertor, coma, lividity of face," and one examination of the pupils of one man, found them contracted. The autopsy discovered neither congestion nor accumulation of blood in the brain. The lungs were congested to blackness, there was a collection in the right heart and the adjoining vessels. "The chief seat of mischief was in the chest and not in the head."

In 1836 Dr. Robert M. Huston,[2] as stated in his discussion of Dr. Pepper's paper of 1850, witnessed four post-mortem examinations of men sunstruck while working in a culvert, and was amazed to find no congestion of the brain.

In the period of 1811–1814, fifteen cases of heat effect were treated at the hospital, with a mortality of three. The recognition by Condie, in 1818, that artificial heat and the indirect as well as the direct rays of the sun were exciting causes of what was then known as *coup de soleil*, or heat apoplexy; his perception that the effects of this condition were chiefly twofold and widely differing in form and treatment; the discovery by Gerhard, in 1830, that, contrary to centuries of conviction, the pathology of the condition was quite distinct from that of apoplexy; the report by Andral, in 1831, of petechiæ, of liquid blood, of pulmonary, cerebral, and venous engorgement, and of contracted heart as the characteristic pathology of this condition, which he did not interpret correctly, but which was later verified as the true morbidity of this state by Russell (1834), Bernard (1858), H. C. Wood (1863), and Stiles (1864)—these are the most noteworthy discoveries of this period.

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[1] J. J. Russell. The London Medical Gazette, vol. xviii. p. 71.

[2] Transactions of the College of Physicians, 1850.

PERIOD IV.—1841-1870.

Heat, Artificial as Well as Solar, Experimentally Demonstrated the Exciting Cause. Success of Refrigerating Treatment.

In 1841 Dr. Thomas M. Markoe[1] reported among a number of cases treated at the New York Hospital, one, Case IV., entitled "Congestive Apoplexy from Drinking Cold Water," the history and post-mortem examination of which classify it as a fatality from heat. The first use of ice water affusions is recorded in the treatment of this case. Autopsy, eighteen hours after death, discovered severe venous congestion of the brain, the sinuses to be swelled with darkened blood, the membranes to be darkened, and the brain on section to exhibit bloody points. There was no extravasation. Blood flowed from the divided vessels at the base of the brain. The complete details of this case help to accentuate one's surprise at the diagnosis.

In 1841 Dr. Bennett Dowler,[2] of New Orleans, published a paper, entitled "Solar Asphyxia, Coup de Soleil, or Sunstroke." It begins as follows: "In the numerous works written or republished in the United States, I have not seen any satisfactory notice of this very frequent and, in the South, most fatal of all maladies." Ten and nineteen years later Drs. Pepper and Lovick, respectively, regret the lack of literature on this topic even at those later dates. Dr. Dowler's paper is remarkable for its breadth and detail of observation. As the isolated study of one man it is very accurate and long antedates corroborative publication by others. Two of its last pages (215, 216) are well devoted to a clear differentiation between sunstroke and apoplexy, which for years later were confounded commonly. The name *Solar Asphyxia* was adopted by him "several years before" he "had an opportunity of testing by dissections the character of the disease, which"—he claims—"it so fully expresses." He adds, "*Pulmonary apoplexy* is a name more characteristic of the morbid appearances of the lungs, but it makes no allusion to its solar origin or to the symptoms of suffocation which mark its progress."

Thus, knowledge of the congested condition of the lung in the major form of heat effect was recognized clinically by Dr. Dowler before its verification by him at autopsy. His observations were more detailed and comprehensive than those of Dr. Russell, made in 1834 and published in 1836. Dr. Dowler states his observations and nomenclature to antedate, by several years, their publication in 1841. The earliest case he cites, he attended in 1836.

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[1] T. M. Markoe. A Report of Cases Treated in the Second Surgical Department of the New York Hospital. THE AMERICAN JOURNAL OF THE MEDICAL SCIENCES, 1841, n. s., vol. ii. p. 343.

[2] New York Medical Gazette, 1841, vol. i. p. 209.

He next presents the practical importance of the classification of solar diseases, and submits the following: 1. Solar exhaustion or syncope. 2. Solar or sun pain. 3. Solar excitement or inflammation. 4. Solar asphyxia, which he makes "the principal subject of investigation." He first distinguished between the two extremes, saying: "Solar exhaustion differs from solar asphyxia, both in symptoms and treatment. In solar asphyxia the skin is extremely hot, and generally dry; there is a choking sensation and a total loss of sense. In solar exhaustion, the skin is moist, pale, and cool; the breathing is easy, though hurried; the pulse is small and soft; the vital forces fall into a temporary collapse, the senses remaining entire." The conditions described are, undoubtedly, those we know to-day respectively as *heat* or *thermic fever*, and as *heat exhaustion*, and the treatment advised for solar exhaustion is the same as that now in use for heat exhaustion. This is the first publication of these distinctions of the results of heat. Dr. Condie assigns his *recognition* of them to 1818, but he did not *publish* them until 1850, and he correctly ascribed the conditions observed to heat, whether of solar influence or not. Whereas, Dr. Dowler says: "Solar and terrestrial heat differ essentially in their action; on health the latter seems never to produce any morbid effects, resembling sunstroke, though many firemen in boats, foundries and furnaces are exposed to a high temperature." On the other hand, Dr. Condie lacked Dowler's clear conception of the differences between heat effect and apoplexy. This is apparent in Dr. Condie's discussion of Dr. Pepper's paper, when he says: "That the direct influence of intense solar heat may produce congestion of the brain and apoplexy, Dr. Pepper admits, and Dr. Condie has known it to produce well-marked meningitis."

To return to Dr. Dowler's classification of solar diseases, he thus defines Classes II. and III.: "II. Solar, or, as it is commonly called by the people, *sun pain*, is a chronic disease in which the abdominal organs are more or less deranged, though the most remarkable symptom is a pain in the head while the sun is above the horizon." "III. *Solar excitement* or *inflammatory reaction*, sometimes follows solar asphyxia of the second degree, being attended with febrile heats, arterial throbbings and headaches." Classes II. and III. would be considered, at the present day, as different degrees of meningeal congestion or inflammation from heat.

Want of acclimation he considers strongly predisposing to solar disease, which he pronounces an urban disease affecting those not thoroughly acclimated to the city. The most thoughtful explanation of why heat effects are chiefly confined to large cities is furnished by Dr. Lente (p. 501). Dr. Dowler quotes the great fatality on the "Liverpool" (p. 491) as an instance of lack of acclimation. He notes that he has seen but one negro die of sun exposure—that the disease is practically confined to males; females, comparatively, being unexposed to the sun. He knew only of one woman to be affected, she happened to be a negress, and recovered. But even the negro, though not prone to fatality, required acclimation. "Slaves from Missouri, Virginia, and Maryland suffer as much if not more from debility than the whites during the first and second summers." "Even horses are debilitated, often get the *thumps*, and frequently die from solar asphyxia during the acclimation period. This is so well known that an acclimated horse or mule is worth much more than one not so protected."

Among his enumeration of the predisposing causes of solar asphyxia —*i. e.*, heat or thermic fever—are a full meal, unsuitable clothing, and fatiguing labor. He erroneously considered exposure to the direct rays of the sun as the only exciting cause of the symptoms he witnessed. That the same phenomena could result from artificial heat was outside his experience. He explains that the man struck down in the street with solar asphyxia is commonly mistaken for an apoplectic, some of the bystanders put ice to his head, "and the first bleeder that can be had performs blood-letting." He records a case of solar asphyxia that he bled with successful result at the instant of onset, also a case of solar excitement—meningitis—that it cured. Referring to the first case, he says: "In this case, blood-letting was probably useful, but in nine cases out of ten it is useless, if not worse, accelerating the death from five to fifteen minutes. During the last five years I have been called to see a very considerable number of sunstruck persons, within five or ten minutes after they fell in the streets; formerly I used to bleed them, and, though *the great heat of the body is thereby suddenly diminished*,[1] the pulse becoming soft as air, yet by the time the arm is tied up (which is done more for form than necessity), the patient is choked suddenly, and to appearance, by a tenacious mucus, the breathing not ceasing gradually as in other disease, but instantly, the face turning livid, and even its veins, especially upon the forehead, becoming at the moment distended. Bleeding hastens the strangulation, though it is always desired by the friends."

While he condemns bleeding in general he states that its instant performance is the only possible hope of those stricken with solar asphyxia of the first degree, which he considers as practically fatal and within half an hour if the onset occurs in the most heated part of the day. The application of ice to the head and the pouring of ice-water over the head and neck are enumerated in conjunction with general sinapisms as methods of treatment employed in solar asphyxia, but they are not specifically commended. This is the first mention I find of the use of ice and of ice-water affusions. He gives an elaborate description of the symptomatology of solar asphyxia and notes as do other early observers the inability of the grave cases to swallow. He expresses the opinion that it was hurtful to attempt medication by mouth as increasing the tendency to strangulation. "In the act of dying, he noticed a slight curving of the body laterally,[1] with a feeble contraction of the fingers. In solar asphyxia, the symptoms and the manner of death are more uniform than in any other malady. *The heat of the body, both before and after death, is a most remarkable circumstance.*[2] In the hurry incidental to a death so sudden I have not had an opportunity of applying the thermometer, to ascertain the exact temperature; but judging from the sense of touch alone it would seem greater than in the hottest fevers. The heat may be felt, radiating from the patient's body, at a distance of two or three feet. In cases where the patient has not been bled copiously the heat is very pungent. The heat of the body continued, generally many hours after death, including the whole night. This is the more remarkable, as our nights are not hot and sultry, but accompanied with breezes, which, by morning, cool even the walls and pavements."

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[1] Italics introduced.

"*After the death of the lungs, or the cessation of respiration, the heart and arteries will, in some instances, continue to act.*"[3]

This remarkable paper, which also contained much data here unnoticed, and the report of several cases, the first occurring in 1836, thus concludes: "The solar heat probably accumulates upon the surface of the body faster than nature can refrigerate through the lungs and the skin by evaporation; inequilibrium presses upon the vital energy, which, being exhausted in the contest, as well as by excessive labor, is unable longer to neutralize the excess of temperature—often 40° F. more than that of the body. Vital chemistry is unequal to the task of preventing the conduction of heat into the body, and death is the consequence."

The explanation of "the vital chemistry" was not successfully attempted until it was begun by Claude Bernard, in 1858, carried further by Stiles in 1864, and far advanced toward completion by Dr. H. C. Wood in 1872 (see pp. 509 and 514).

In 1845 Dr. Dowler,[4] who had for some time been studying the ante-mortem and post-mortem thermometry of yellow fever and of many other diseases, published in September the following most interesting observation, both medically and historically:

On July 24, 1845, he observed in a case of "solar asphyxia," twenty minutes before death, an axillary temperature of 111° F. One hour after death the thermometer registered 113° F. From that time the cadaveric temperature began to decline. Nine hours after death the temperature was 109¾° F. The observer makes the following comment:

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[1] Lateral convulsive contraction was noted by the reviewer in one case observed by him in 1892.

[2] Italics introduced.

[3] This opportunity occurred in 1845, and the temperature then recorded was the first reported of cases suffering from heat effect.

[4] The Medical Examiner, Philadelphia, 1845, n. s., vol. I, p. 528.

"I have had much experience in this malady, but never happened to take my thermometer with me before; but I am convinced that solar asphyxia, in the first degree is the hottest of all maladies, and can hardly be less than 120° F. in many cases! The patient seldom has more than *one premonitory symptom—a sudden dryness and heat of the skin.* I suppose that this man's heat was below the average; certainly not so great as some others, according to my touch."

This seems, without doubt—the language is so explicit—the first thermometric observation of heat effect made by Dr. Dowler, although Dr. Levick[1] credits Dr. Dowler with the record of an ante-mortem observation of 99° F. and a post-mortem observation of 104° F. in a case of heat effect on May 3, 1844, a year earlier than the case cited, but no reference is given. Either is as far as the reviewer knows, the first thermometric observations ever made of the effect of atmospheric heat on man.

In 1846 Dr. Geddes[2] reports a case of heat effect developing in a convalescent from measles in a hospital ward. This is the first published report of heat effect not caused by solar heat. The case reported by Condie is of prior date, 1818, but was not published until 1850.

In 1846 Dr. Israel Moses[3] published a report entitled "Exhaustion by Heat and the Effects of Cold Drinks when Heated"—the context suggests *when the drinker is heated*—was meant. Sixteen cases are reported. They are classified, in brief, as cases of apoplexy, exhaustion, and effects of drinking cold water.

As in the paper of Dr. Carroll (p. 491), the prefatory classification is not carried out, and detailed histories show that undoubted cases of heat are erroneously considered as cold-water effects, Rush and Currie being quoted. Six of the cases died, of which four were bled. The author considers bleeding contributory to fatality, and advocates treatment by the hot bath 104° F. to 108° F., "aloetic enemata," sinapisms and frictions.

The six fatal cases were examined post-mortem, the lungs being congested in five, and not markedly so in Case X. The brain was found congested in Cases I. and IV., the membranes in Case VI., Cases VII. and VIII. were too much decomposed for examination; in Case X. no marked congestion was observed.

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[1] Pennsylvania Hospital Reports, 1868, vol. I. p. 382.

[2] Geddes. Clinical Observations of Diseases of India. London, 1846. See Sunstroke, H. C. Wood, Philadelphia, 1872, p. 10.

[3] Israel Moses. The New York Medical and Surgical Reporter, 1846, vol. I. p. 11.

In 1849 Dr. Henry Hartshorne was the first of the staff of the Pennsylvania Hospital (he being a resident physician) to publish a report[1] of *coup de soleil.* He described four cases treated in 1846; two were fatal, the second was a chronic alcoholic, and the third died on admission. He notes that several other cases occurring in the city at the same time all proved fatal. His treatment is advanced and interesting, and he records the first use at this hospital of ice and of the cold douche to the head. Two of his cases were bled, but with difficulty, by cupping at the back of the neck: one died, the other recovered. Sinapisms were applied to the abdomen and legs. Aromatic spirits of ammonia were given by the mouth, and turpentine by the bowel. One case, while having cold applied to the head, was placed in a warm sitting bath.

In 1850[2] Dr. William Pepper, the elder, reported before this College twenty cases treated at the Pennsylvania Hospital in the seven[3] preceding years. Of these ten died, seven recovered, and three, partially recovered, became insane. All of these cases had been bled before admission to the hospital. Dr. Pepper reports symptoms and post-mortem appearances. Both these conditions were possibly modified by the bleeding to which the patients were subjected before being admitted into the hospital. The "pallid, flaccid, and softened" condition of the heart noted in four cases by Dr. Pepper and reported in one by Dr. Reed in discussion, were also due, probably, as suggested by Dr. Stiles,[4] to post-mortem change, the autopsies being made six to eight hours after death. Autopsy was found impracticable by Dr. Levick[5] ten hours after death. Dr. Horatio C. Wood[6] makes the following suggestion in regard to these cases. "The cases were very probably true sunstroke and not simply heat exhaustion, as I have suggested, and the cool skin was the result of the bleeding. The soft, flaccid hearts were found because the temperature not being high at the time of death the cardiac myosin did not coagulate."

Dr. Pepper says: "The disease is evidently one of nervous exhaustion. The cases of apoplexy and congestion of the brain occasionally produced by insolation should be carefully distinguished from the cases above alluded to, the pathology and treatment of the two being very different." *Again:* "The cases we usually meet with during the intense heat of our summers present no symptoms similar to those which result from cerebral congestion, and demand for their cure stimulants instead of bleeding." Dr. Pepper closes by commenting on the absence of satisfactory medical literature on the subject at that day. This was the first presentation of this topic to the College of Physicians, and it is also the first, though not a very clear report by a member of the staff of the Pennsylvania Hospital and by a Fellow of the College of the difference between exhaustion and congestion following exposure to the sun.

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[1] The American Journal of the Medical Sciences, 1849, n. s., vol. xviii. p. 66.

[2] Ibid., 1851, n. s., vol. xxi. p. 183.

[3] The hospital records for this period, and for ten preceding years, show the admission of but fifteen cases, six of which died and nine recovered.

[4] Boston Medical and Surgical Journal, 1861, vol. lxx. p. 349.

[5] The American Journal of the Medical Sciences, 1859, vol. xxxvii. p. 49.

[6] Wood. Sunstroke. Philadelphia, 1872, p. 107.

Dr. Condie, in discussion of Dr. Pepper's remarks, gives a most clear and differential description of the symptoms of exhaustion from heat, and also—which Dr. Pepper did not—of congestion (fever) from heat. As already cited (p. 489), his recognition of these conditions dates back to 1818, and has such priority but not that of publication. He also makes distinction in the treatment, condemns bleeding for heat exhaustion, and, on the other hand, tells how he saved life by bleeding in a case of heat congestion accompanied by convulsions. His belief that heat effect may result in apoplexy has already been noted (p. 496). Post-mortem examination of the brain convinced him that "these cases are dependent upon acute meningitis." His is also the first recognition that artificial heat as well as solar heat can produce the condition at that time only attributed to the sun.

Dr. Reed also took part in the discussion, reporting a case which was subsequently examined post-mortem, a foot-note states that the heart in this case was flaccid.

Dr. Parrish closed the discussion. While acknowledging the value of Dr. Pepper's observations, he noted that they were in opposition to the prevalent doctrines of congestion and inflammation applied to all violent diseases which destroy life.

On page 536 of the same volume of THE AMERICAN JOURNAL OF THE MEDICAL SCIENCES, Dr. Frederick D. Lente, resident surgeon at the New York Hospital, answers Dr. Pepper's expressions of surprise that there was so little and such vague literature upon this subject: The victims of heat are principally laborers in cities "who earn their daily bread by their daily work, and are consequently compelled usually to labor during the intensest heat of the day, when the thermometer in the shade ranged from 96° F. to 100° F., and over, with not only the direct rays of the sun playing upon them, but also the reflected rays from the pavements and buildings. Added to this as the efficient and exciting cause, we have fatigue, intemperance, and often insufficient or improper food as predisposing agencies; these causes usually do not exist in the country and in small communities," etc. The city heat subjects are attended by private physicians only in emergency, being usually summoned to the relief of a man "who has fallen down in a fit while at work." These cases are, therefore, bled—hence, Dr.

Pepper's cases were all bled before admission—and sent to hospital. The majority are admitted between the daily visits of the chief, and so are practically only observed by the resident physician, "who in the discharge of his multitudinous duties" takes no particular notes of these cases. It follows that there is little and vague literature. Dr. Lente reports that in 1847 thirty-seven cases occurred in four days, most of them dying so promptly as to be attended only by the coroner. Animals, omnibus horses especially, were also stricken. Of *forty-two* cases admitted into the New York Hospital in the five preceding years, *twenty-four* died, and eighteen survived. In eight post-mortems there was congestion of the lung in two, and of the brain in four. There was no evidence of inflammation of the brain. One of the most discriminating observations of this paper is that the prognosis depends upon the stage in which the case is seen. So that one "physician might have ten cases, and all might recover; another might have the same number, and the treatment be equally judicious, yet nine out of the ten might die."

In 1852 Dr. C. A. Gordon,[1] an English army officer, had under his care in India, a number of cases of sunstroke, which he reported in 1857, stating that apoplexy and *coup de soleil* include the same conditions of body. Of the twenty-eight cases of heat effect that came under this author's notice but one recovered. His paper is important as bridging the epochs in one of which the effects of heat were ill-described as apoplexy, while in the other the terms insolation and sunstroke evinced a correct appreciation of the exciting cause in some cases, although both terms are too restricted in meaning to embrace the bodily effects of artificial as well as of solar heat.

Dr. G. S. Beatson, staff surgeon of the first class, English Army, criticises the paper of Gordon, because he stated that apoplexy and sunstroke included the same condition of the body and constituted one disease. Beatson admits the close connection between these diseases, but denies their identity in pathology and in treatment if the latter is to include blood-letting. He inveighs against the latter, and quotes fatality as a sequence, and suggests it to be consequence. He opposes to Gordon's almost certain mortality in all cases of this affection a report of eight to ten cases treated in India, in which but one case was bled, and with fatal result, and the remaining cases which were not bled recovered. The treatment of the latter included the removal of the patient to a cool place, the loosening of his clothes, and effusions of cold water on the head, chest, and epigastrium.

In 1853 Dr. T. H. Bache, resident physician of the Pennsylvania Hospital, as he reports in a discussion of Dr. Levick's paper read before this College in 1858, attended a number of sunstroke cases—they were mostly fatal (six out of ten cases)—and the post-mortem condition of the *heart was not softened*, as reported by Pepper of the cases he had seen.

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[1] Medical Times and Gazette, London, 1857.

In 1854 Dr. H. S. Swift,[1] resident physician of the New York Hospital, published his "Observations on Exhaustion from the Effects of Heat (*Coup de Soleil*)." This paper is important as marking a period of some advance and certainly in knowledge concerning heat effects.

The author states that the sixty cases he reports were admitted to the New York Hospital in the "past summer" were of the class at first called *coup de soleil*, but later regarded by the profession as prostration from heat, "combined, perhaps, with the effects of large draughts of cold water." The city inspector reported for that year 260 deaths from *coup de soleil*, without including many cases designated as "congestion of the brain and the effects of cold water." Dr. Swift finally dismisses this topic, saying, "Deaths from the effects of cold water are not so frequently met with as is generally supposed," and then quotes Dr. Dickson, who (p. 492) scouted the production of heat effects by cold water. As the paper of Dr. Moses is the last one found that refers to this subject by title, so is the paper of Dr. Swift the last to at all consider it, unless reference is made to that of Dr. James Trask, who published an account of "Alarming Effects from Drinking Cold Water after Violent Exertion in Cold Weather—February." The symptoms in this case were similar to those of shock, and in no way resembled those of heat effect. The case would not suggest comment in these pages but for Dr. Trask's closing sentence: "The appearance of this man (the patient) resembled that of most persons suffering from the too free use of cold water in the hot weather of summer; the sudden ingestion of a large quantity of cold water causing congestion of the brain." This sentence is the last expression of this opinion found by the reviewer. Its date of publication is 1859, twenty-eight years subsequent to 1831, when the last entry of "effects of cold water" appeared on the records of the Pennsylvania Hospital, where this curious error in diagnosis originated in 1769.

Of the sixty cases reported by Dr. Swift, eleven occurred in a hotel laundry, and several in a sugar refinery. Eight of the sixty cases were women, who, as a class, are unexposed to the sun. These data confirmed the view of Dr. Condie suggested to him by a case occurring in a heated room in the winter of 1818, and the report by Dr. Geddes, in 1840, a case originating in a hospital. They rendered untenable the opinion of Dr. Dowler that the direct rays of the sun (p. 496) were essential to pathological results from atmospheric heat, and, moreover, created a need for new and precise terminology descriptive of heat effects in man.

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[1] Swift. The New York Journal of Medicine and Collateral Sciences, 1854, n. s., vol. xiii, p. 45.

The phrases current at this time for heat effect were apoplexy from heat, *coup de soleil*, sunstroke, insolation, ictus solis, erethismus tropicus, heat exhaustion, nervous debility from heat, and the terminology of Dowler (p. 496). Russell (p. 494) was the first to publish (1836) his knowledge gained by autopsy, that the major form of heat effect was not apoplectic and was coincident with engorgement of the lungs. Dowler, independently, reached the same conclusion by clinical observation (1836), confirmed it later by post-mortem section, and in 1841 published a differential diagnosis between apoplexy and heat effect. He at this time seems to have stood alone in the combined knowledge of the following data:

1. That heat effects were not associated with apoplexy.
2. That they were accompanied by pulmonary engorgement.
3. (*a*) That they consisted of two principal, widely differing varieties, one of "exhaustion" and the other of "asphyxia," or, as would be said to-day, of fever—which he was the first to recognize thermometrically (1845); (*b*) that the treatment of these conditions was in strong contrast, blood-letting being contraindicated in cases of exhaustion, and advisable in selected cases of asphyxia or fever; (*c*) that there was an intermediate and sometimes sequent condition which he respectively recognized under the titles of "pain" and of "excitement or inflammation," and which are now grouped under the single title of meningitis. His predecessors and for twenty years subsequent to 1841, the date of publication of his first paper, his contemporaries confounded the effects of heat with apoplexy. Thus, some authorities maintained that cerebral congestion was always present in heat effect and always demanded depletion. Others held that nervous exhaustion was the only pathological result from heat, and that blood-letting was never permissible. Others again recognized that effects of heat might be exhaustive or congestive, but went astray by identifying fever with apoplexy, cold-water effect, etc.

This confusion of ideas resulted in a babel of tongues, so that *coup de soleil*, insolation, etc., were used by different authors with varying significations and limitations of application. The paper now in review, that of Dr. Swift, typifies this chaos of thought and nomenclature as well as marking, as already noted, a period in which speculation began to crystallize into precise knowledge.

The following quotations from Dr. Swift, as well as those from Dr. Pepper's paper (p. 500), illustrate the contention and misapprehension prevalent on this topic at that day:

" It is now only five or six years since the nature of this disease was pointed out, and yet the profession, generally, have but vague and indefinite ideas respecting it, and it is a matter of surprise that medical literature is so deficient on the subject."

As evidenced by the references in the foregoing pages, and they are but a suggestion of the publications on this subject, the quantity of literature was not so much at fault as the availability of knowledge of its existence.

Again: "The term *coup de soleil* as applied to this disease is a misnomer. It is a popular rather than a professional appellation. All our authors agree that 'cerebral apoplexy' is occasionally produced by exposure to the direct rays of the sun. This I regard as true *coup de soleil.* The subject now under consideration is an entirely distinct affection. It is now almost universally admitted to be mere nervous exhaustion produced by protracted and violent exercise in an overheated atmosphere."

"Of the large number of cases observed by me, none were strictly apoplectic, and no lesions were noticed in those which proved fatal, sufficient to account for death. These two opposite conditions—the 'cerebral congestion' and 'nervous debility'—require opposite modes of treatment, and should be carefully distinguished from each other." The "cerebral apoplexy occasionally produced" by the sun was current belief. "Of the large number of cases—60—observed 'by him' none were strictly apoplectic," is definite knowledge gained by investigation; nevertheless, current belief, and "all our authors" are not repudiated —but evidence is presented to that end. The reference to "the subject under consideration being mere nervous exhaustion" would mislead to the belief that the minor degree of heat effect as described by Dowler and observed to-day was meant by the author, did he not quote Dowler's description in contrast to his own, and give a most discriminating and detailed symptomatology dividing the condition in mind into three stages: 1. That of onset. 2. That of the course, in which "the skin is hot," "the temperature 112° F.," "according to Dowler." 3. The stage of collapse; this leaves no doubt in the reader's mind that the major form of heat effect is classed under the title of nervous exhaustion.

In a well-marked case that had been classed as having apoplectic symptoms and was bled, death occurred in twenty-one hours. The autopsy, performed eighteen hours later (too late to permit reliable observations—reviewer), discovered no marked congestion of brain or lungs, and a flaccid heart filled with fluid blood. The liver was much congested, other organs healthy. He comments as follows:

"This case was doubtless one of 'nervous exhaustion,' a condition so often mistaken for and associated with 'cerebral apoplexy,' and it was the only one in which reaction ran sufficiently high to indicate depletion. But even in this the post-mortem disappointed us. I have only seen a few, a very few, cases of insolation verified by post-mortem examination—certainly, not *one* during the past year, although examinations were made *in all the cases* in which we suspected any cerebral lesion."

The following paragraph notes a radical change in treatment: "Blood-letting is now nearly abandoned. Formerly nearly every case treated before admission to the hospital had been bled. But not a *single patient* had been bled of those admitted during the past summer. They do not bear well even the local abstraction of blood by cupping."

It was the period of reaction. Before laying down this very interesting paper, it will be well to note some of its statistics: The total number of cases admitted to the New York Hospital from 1845 to 1854 was 150, of which 78 died. The number of cases under Dr. Swift's observation was 60; the mortality more than one-half. On admission 44 cases were insensible, 16 stupid or sensible; the pupils were dilated in 30, contracted in 19, and natural in 11. The temperature of the body was hot in 34, warm or natural in 11, cool in 18; respiration hurried in 44, pulse uniformly accelerated 100 to above 160; convulsions in 24; delirium in only a few; 52 were males; and the average duration of fatal cases about four hours. "In 33 fatal cases the pupils were contracted in 20, moderately dilated in 7, and markedly so in 6; while in the successful ones the pupils were dilated in 19, and nearly natural in 16. No case recovered in which the pupils were contracted. The treatment included the hot bath, sinapisms, enemata of aloes or turpentine and "ice to the head *when the temperature is elevated.*" . . . "Indiscriminate use of cold affusions is productive of harm. Injurious and often fatal effects result from them."

In 1854 Dr. J. R. Leaming, in the same number of the *New York Journal* as the paper of Dr. Swift (p. 58), advises for heat effects the use of hydrochlorate of ammonia in 8-grain doses. The suggestion is made from the employment of the drug in four cases concerning which the author truly states his notes to be "very meagre."

In 1856 Dr. Sanford B. Hunt[1] published his "Observations on the Cause of the Disease Known as Sunstroke." In this paper, dealing largely but with greater originality and aggression with the facts observed concerning the large number of cases occurring in the service of Dr. Swift, in 1854, reactionary opinion swings further, and in some instances the conclusions are broader than the facts.

He first considers the question:

Are the direct rays of the sun necessary to the production of the disease known as sunstroke?

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[1] Sanford B. Hunt. Buffalo Medical Journal, 1856, vol. xii. p. 23.

He cites that in the sunstroke *epidemic* in New York, August, 1854, of the 235 deaths from this cause, 49 were females. In view of this fact and the comparative non-exposure of females to the sun, added to the occurrence of the laundry and sugar-house cases, and of similar cases, as recorded by the health offices of various cities answers this question, beyond contention, in the negative.

Secondly, is congestion of the brain the special pathological condition in this disease?

Again referring to the cases of Swift, Dr. Hunt says: "At any rate, enough is known to prove that contracted pupils and convulsions are not to be accepted as sufficient proof of congestion, and we must wait for actual post-mortem evidence of it to verify its existence. It is already plain that only a very limited number of cases are congestive, and it is quite probable that that limited number will be much decreased on careful study."

He approves Swift's title of "Nervous Exhaustion from the Effects of Heat" as the designation of the disease, and immediately beneath the second inquiry of the paper says: "It is only recently that the fact has been fully recognized, that in the great majority of instances of sunstroke, the symptoms have been those of syncope or exhaustion." Knowledge of the paper of Dr. Swift and of the fact that he includes under the title of exhaustion major cases of heat effect, make it plain that Dr. Hunt like Dr. Smith used this term in error, because too broadly denominating by it, heat effects of hyperpyretic character as well as those of exhaustion from heat to which the phrase should be limited as suggested by Dr. Dowler and practised to-day.

What are the facts in relation to heat as a cause of coup de soleil?

He answers this question by quoting meteorological data in evidence of a greater number of cases of heat effect occurring on hot humid days than on hotter days but of dry heat.

He states: "The facts adduced are conclusive that, though a certain temperature is necessary, neither the frequency or the fatality of the disease increase with a further rise of the thermometer. Heat is not the essential cause; neither are the direct rays of the sun necessary."

"What then is the essential condition for the production of *coup de soleil*, or rather exhaustion from the effects of heat?"

"High humidity is the essential condition. This opinion is based upon weather records and upon analogy."

"In the first place the condition of nervous exhaustion is never produced by a high, dry heat."

Dr. Hunt disclaimed originality for his views on the etiological influence of the disease "known as sunstroke," yet such a claim would have been pardonable, considering that he is the first to present the scientific evidence of hygrometry in support of an observation probably first published by Lancisi, as already noted in 1694. It hardly is necessary to say that the influence of humidity in the production of heat effects is generally acknowledged, but when Dr. Hunt says that they are "never produced by dry heat"; "that, though a certain temperature is necessary, neither the frequency or fatality of the disease increase with a further rise in the thermometer;" and finally, "that the essential condition for the production of *coup de soleil* is high humidity and not heat," he goes too far. The paper, as a whole, is one of much originality, force, and some discovery; it finally refers to the institution of "experiments to determine as to what power a humid atmosphere exerts on the absorption of the solar rays," and the message of the author is best expressed in his sentence saying, that "examination of such weather records, corresponding with periods of mortality from sunstroke, as have fallen under 'his' notice, have uniformly resulted in fixing a high temperature of evaporation as the efficient condition of the cause of the disease, and that without definite relations to the dry bulb temperature."

In 1856 Dr. J. B. S. Jackson[1] reported a case of recovery from sunstroke which occasioned discussion in which Dr. Strong presented a classification of cases into two groups not very clearly described.

Drs. Parkman, Cabot, Bigelow, Senior, and Coale also took part in the discussion.

In 1856 Dr. Charles Morehead,[2] in the first edition of his *Researches on Disease in India*, treats of the pathological effects of heat under the headings of "Apoplexy" and "Cerebral Affections Caused by Elevated Temperature."

In his consideration of apoplexy he at once distinguishes between a "correct" use of the word as signifying cerebral *congestion*, with or without effusion or hemorrhage, and a looser use of the term, including in its meaning cerebral "*determination*" as applied to the effects of excessive heat or of alcohol. He quotes statistics in evidence that heat effects were often and erroneously classed as apoplexy.

In treating of "Cerebral Affections Caused by Elevation of Temperature" he makes a triple classification of symptoms, which, it is plain, are those of three stages in the major form of heat effect. He records that the pupils in the cases he observed were primarily contracted, but finaly dilated—an observation later confirmed by Dr. Stiles' experimental investigations.

The pathology noted includes vascular turgescence of the membranes and substance of the brain, posterior congestion of the lungs, engorgement of the venous circulation and of the right heart with badly coagulated blood. Phrenitis and encephalitis are pronounced of rare occurrence.

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[1] J. B. S. Jackson. Extracts from Records of Boston Society for Medical Improvements, 1856, vol. ii, p. 9.

[2] Morehead. Clinical Researches on Disease in India, London, 1860, first edition, vol. ii. pp. 577-582.

The following paragraph presents a "suggestion" that has claim to priority, and that anticipates some of the conclusions derived from experiments reported three years later by Bernard:

"Active cerebral determination of blood takes place as a consequence of exposure to elevated temperature, and coexists with the symptoms above detailed; but it may be doubted whether it is a sufficient explanation of the proximate cause of the phenomena. From a review of all the attendant circumstances it seems to me not an unreasonable suggestion to offer that *the temperature of the blood may become much increased, and to this altered condition of the blood the deranged actions may in part be due.*[1] The nature of the cause and the pungent heat of the surface of the body, which is invariably present, may be used as grounds for this opinion. The tumultuous action of the heart is also a characteristic symptom, and seems to me to point to a direct influence of the *cause* on that organ."

Although Dowler was the first to measure the degree of elevation of temperature, he, like Russell, attributed the chief cause of fatality to the lungs. Morehead was the first to suggest the abnormal elevation of the temperature of the blood to be the primary cause of trouble in heat effects, and its *direct influence* to be secondary.

In 1857 Dr. B. Darrach,[2] resident physician in the New York Hospital, treated four cases by stimulants and by *rubbing the entire surface of the body with ice;* three of his cases recovered, one died. He reports the cases equal in severity to four previous cases in which the ice was only applied to the head, and all four patients died. This is the first report of the application of ice to the whole body in the treatment of this condition.

In 1858, Claude Bernard[3] announced in his lectures to the College of France that the temperature of mammals and birds could be elevated 4° C. to 5° C. (7.2° F. to 9° F.) above normal, and that the animals, without exception, died when their temperature became elevated to this degree. On autopsy, the *heart* and other muscles of the body were found *rigid.* In the history of the pathology of the major form of heat effects, this communication is only second in importance to the first observation of temperature in this disease, by Dowler in 1845. The significance of the phenomena observed by Bernard will become more apparent with the reading of his report of further experimental data and of his deductions.

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[1] Italics introduced.

[2] Darrach. New York Journal of Medicine, 1854, n. s., vol. xii, p. 45.

[3] Bernard. Lectures to the College de France, 1858, vol. iv, p. 209.

In 1858 Dr. Levick[1] reported to the College of Physicians twelve cases treated that year at the hospital; one of these cases occurred in a sugar refinery, three cases died, and also a cured case suddenly on the sixth day after recovery. Dr. Levick notes the differences between exhaustion and congestion as bodily results of heat, and urged that for these dissimilar conditions different modes of treatment were required, and that, therefore, diagnosis was important, and he italicizes his belief that the process is most frequently one of exhaustion. He deemed none of his cases in need of bleeding. He comments upon the coincident value of turpentine in the treatment of malignant fevers and of sunstroke. He notes the post-mortem appearance of the blood in typhus to resemble that in sunstroke; that putrefaction in the latter disease was so rapid as to prevent autopsy ten hours after death; that in the last case reported symptoms of inflammation of the brain were corroborated by post-mortem discovery of extensive inflammation of its base.

In January, 1859, Dr. Levick[2] contributed to THE AMERICAN JOURNAL OF THE MEDICAL SCIENCES the most comprehensive history and analysis of this subject published at that time, and to the references of which this review is much indebted. In confirmation of artificial and solar heat being alike productive of the same symptoms, as evidenced by the cases reported by Swift, Dr. Levick alludes to the case already noted, which he reported the previous year, and which developed in a sugar refinery. Contrary to first impressions, he subscribed to the observations of Dr. Hunt with regard to humidity being an etiological factor "of the disease known as sunstroke," but Dr. Hunt's assertion that disease from heat is "never produced by a high, dry heat" is disproved by Dr. Levick, who quotes the case detailed by Russell as occurring "at a season when the hot land winds had just set in, rendering the atmosphere dry and suffocating."

Dr. Levick, like Andral, comments upon the coincidence of atmospheric heat, and the epidemics of apoplexy noted by Forestus, in 1562; but while Andral would confirm this observation, Dr. Levick maintains that the epidemic character of the disease in hot, humid weather is only explainable by the inference that at least many of the cases were *not* due to apoplexy, but to the effects of heat.

He notes and accepts the post-mortem observations that establish apoplexy and heat effects to be dissimilar conditions, and also those concerning the fluidity of the blood and the general venous and especially pulmonary engorgement. He again comments upon the rapidity of putrefaction noted by him the year before. He quotes Pepper, Lente, and Swift in agreement upon the flaccid condition of the heart.

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[1] Levick. THE AMERICAN JOURNAL OF THE MEDICAL SCIENCES, 1858, vol. xxxvi. p. 404.

[2] Ibid., 1859, vol. xxxvii. p. 40.

He by inference condemns blood-letting. He advocates cold affusions and the use of ice to the head in selected cases. He warns that "the full bath is not without danger." The chief indication for its use is found in the stimulus afforded by the *hot* bath. He finally quotes the "happy results" obtained by Dr. Darrach in "frictions of the body *with ice*" to relieve the burning heat of *the skin*, which is justly viewed as a most unfavorable prognostic symptom. Carbonate of ammonia and the aromatic spirits are recommended for administration by the mouth, and oil of turpentine by the bowel.

This very exhaustive article closes with the following reference to sequelæ which are best presented in the words of the author, as future reference will be made to it:

"After the immediate symptoms of an attack have passed, as after cholera, typhus fever, etc., so with sunstroke, various internal inflammations may be developed—as of the brain, the lungs, etc.—which require a treatment entirely unlike that mentioned above. In this way we have cases reported as meningitis resulting from exposure to heat; but according to my observation, these differ from sunstroke in their gradual mode of attack, although just as apoplexy may occur in warm weather, so may meningitis; but in by far the greater number of cases of sudden attacks of illness from exposure to heat, inflammation of the brain is not the pathological condition. Nor must we be misled by the presence of delirium, or of a hot skin, in such cases. The latter we have present even in malignant typhus, and no fact is better known to the pathologist than this; that, in typhus and typhoid fever, phenomena almost identical in character with those of inflammation of the brain may be present, and yet, after death, no lesion of this organ be found. In the words of Dr. Bartlett, when writing of typhus fever, "delirium and somnolence have occurred as frequently, and as strongly marked, in patients whose brains presented no changes, as in those of an opposite character."

It is interesting to note that general frictions with ice were approved by the author for the relief of an "unfavorable *symptom*" affecting the skin and employed empirically. The pathology demanding refrigeration as one of the vital principles in the treatment of the major form of heat effect was not yet understood. That it had been divined, is suggested by the comment of the reviewer (p. 509) on the notes of Bernard. His second announcement, now in order, sheds much light on the pathology of heat effects, implying the essential necessity of employing cold in their treatment.

In February, 1859, Claude Bernard[1] reported the results of two experiments "on the cause of death in animals submitted to a high temperature." He refers to his announcements of the year before and presents the data of subsequent observations and his conclusions.

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[1] Comptes-Rendu des Séances et Mémoires de la Société de Biologie, 1859, Tome III. Series B. 51.

> *Experiment* 1. A rabbit subjected to a temperature of 55° C. to 60° C. (131° F. to 140° F.) fell on its side and died quickly. The temperature of the rectum and thorax taken at once was 44° C. to 45° C. (112° F. to 113° F.). The heart was still, was firmly contracted, and contained no blood. The muscles and limbs were stiff, and did not respond to galvanism. The blood of the ears was black, presenting no apparent alteration of character. Poured in a glass it coagulated well, and the exposure exhibited a ruby red color.
>
> *Experiment* 2. A younger rabbit that had not been permitted to feed preceding the experiment, as had the first rabbit, succumbed a little more slowly to the effects of heat; otherwise the same phenomena were exhibited at both experiments.

He explains the cause of death in these cases to be *due to the purely physical fact of the elevation of the temperature of the blood.* This elevation is such as to be incompatible with the exercise of muscular contractility, and consequently of the cardiac functions. The heart is stopped and becomes incapable of vital functions. The muscular fibres of animals having a precisely similar temperature exhibit after death rigidity and immobility. Dr. Kühne has shown that in these conditions the rigidity was due to coagulation of a special matter contained in the muscle. As he had observed the muscles of animals dying of cold, although rigid, to be of alkaline reaction, he concludes that the usual muscle acidity accompanying cadaveric rigidity should not be considered as a cause of rigidity, since the latter can exist without acidity.

In 1860 Dr. Charles Morehead[1] published a second edition of his *Clinical Researches*, containing an enlarged chapter on "Sunstroke." This title, condemned by the author in his first edition, is employed in the second, and broadly applied to the effects of the indirect as well as the direct rays of the sun. This chapter represents the experience and opinions, unpublished as well as published, of many Anglo-Indian surgeons as well as the personal observation and views of the author. It contains a new classification of symptoms dependent upon an Anglo-Indian recognition that in the effects of heat there are different varieties, which he denominates as follows:

1. Comal, which is cerebro-spinal in origin.
2. Syncopal, which is a cardiac type.
3. Comal and syncopal combined, the origin of which is cerebro-spinal as well as cardiac, and is therefore denominated as "mixed."

The symptoms detailed of the first, or cerebro-spinal variety, show it to be identical with the condition known to-day as thermic or heat fever.

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[1] Morehead. Clinical Researches on Diseases in India. London, 1860, second edition, p. 603.

The second, or cardiac variety, may be subdivided into two types. In one the individual, "without premonitory warning," and generally consequent on direct exposure to the sun, falls down, gasps a few times, and dies.[1] The authority for this instantaneous form is assigned to Dr. Pirrie. Such instant fatality is contrary to the experience of most observers. Rush described it, but his contemporaries Condie and Watt discredited it. Dowler reports instances of death occurring in twenty or thirty minutes, but hours are usually occupied in the fatal progress of this affection. The second form of the cardiac variety is not instantly or necessarily fatal. This subdividing of the cardiac variety is a distinction made by the reviewer, and not the author. The symptoms detailed of this type—for instance, "a cold and clammy skin"—identify it, without doubt, as that of heat exhaustion, in spite of the fact that the author groups in it cases of most unusual and instant fatality.

In the third, or mixed variety, the author assembles atypical cases of the two varieties described, more especially mild cases of the first variety.

On the topics of symptoms, pathology, etiology, and treatment, the author, though at times in disagreement with modern conclusions, often penetrates with clear-minded energy to first causes or perceives indications that were not recognized as true by many observers until years later. Justice can only be done this most instructive chapter by consulting the original.

In 1863 Dr. Horatio C. Wood, Jr., published in THE AMERICAN JOURNAL OF THE MEDICAL SCIENCES a report of eight cases affected by heat, seven of which died; a ninth case that died is recorded in the hospital records, and was probably not under Dr. Wood's care. He expresses his belief that heat produced different classes of cases called sunstroke, but he had observed only the fatal variety which he had reported. Dr. Wood is the first of the staff of the Pennsylvania Hospital to publish thermometric observations of his cases, but the first reports of this character are those of Dr. Dowler. The maximum temperature observed by Dr. Wood during life was 109.75° F., but one hour after death the temperature of 110.75° F. was recorded in one case.

Dr. Wood's report is still unique in its wealth of post-mortem notes. In the six autopsies recorded the following observations were most constant. None but the slightest congestion of brain, meninges, and lungs, although the meningeal and pulmonary veins were loaded with blood. The blood was dark, fluid, tending to acid reaction and not to coagulate. Its microscopical examination in one case is the first recorded in this disease. The red globules were found "a little more opaque than normal, and aggregated in rouleux and masses. No abnormal proportion of white corpuscles." "The *heart* was in all cases *rigidly contracted.* The veins were surcharged with blood." In this, as in other diseases, ecchymoses are characteristic of altered blood. The pathognomonic post-mortem results of fatal blood disorders are like those of sunstroke; "alteration and destruction of the crasis of the life fluid, without structural changes in the solids."

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[1] Pirrie. Insolation, Sunstroke, or Coup de Soleil. Lancet, May 20, 1859.

He states that alterations in the blood produced by heat are responsible for the cerebral symptoms observed, that death is brought on by loss of power in the central nervous system, and he substitutes thermohæmia, or "thermic fever," as the name of the condition in place of sunstroke. The name thermic fever is an advance in specific terminology, because the first word accurately gives the cause of the trouble, and the latter word states the condition resulting from the cause; the two words combined limit their application to the grave form of bodily effects from heat which is accompanied by an elevation of temperature that tends to the extreme. He condemns the prejudice against drinking water, and urges the ingestion of fluids, because the blood has been deprived of its serum, it may be by pints, through the action of the perspiratory glands. He acknowledges treatment to have been futile in his hands, and quotes and suggests Taylor's[1] recommendation of cold affusions as practised in India.

An analysis of Dr. Wood's reports of his cases discovers that cold was employed only in the treatment of three, namely: Cases III., IV. and VI. Cases III. and IV., axillary temperature 109° F., had ice frictions; Case VI., femoral temperature 104° F., was treated with cold affusions, *which aggravated the tendency to convulsion.* Two of the cases were intemperate; the other, temperature 109° F., was sixty years of age. The two cases of 109° F. were not brought to the hospital until two hours after the onset of the attack. The cases of 104° F. had been suffering from the effects of heat four days before admission. These were all unfavorable cases for treatment, and they all died.

In 1864 Dr. R. Cresson Stiles[2] published the results of the first experimental "observations on animals subjected to an elevation of temperature in various modes, and which presented a series of symptoms very closely allied or identical with those of sunstroke as 'he' had seen it, and as 'he' found it described by careful observers." These experiments were inspired by the diversity of existing opinion respecting sunstroke, by a desire to test the accuracy of the "currently received pathology of the disease," and with a prejudice in favor of a poisonous quality being acquired by the blood. This theory he credits to Dr. H. C. Wood, in the publication just summarized. The investigations of Dr. Stiles soon caused him to abandon this theory or rather to "regard the only poisonous property of the blood to be its elevated temperature."

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[1] Lancet, 1858.

[2] Boston Medical and Surgical Journal, 1864, vol. lxx. p. 349.

Dr. Wood, in his *Boylston Prize Essay*, 1872, p. 103, thus concurs with Dr. Stiles: "I believed at that time (referring to his paper of 1863) that the nervous symptoms were due to the development of a poison in the blood;" not perceiving that the heat itself was the poison. His conclusion is formulated in the title of his paper: "Sunstroke, or Paralysis of the Heart by Heat."

He reached his conclusions by five classes of experiments:

CLASS 1. "Those in which warm-blooded animals were subjected to an elevation of temperature; the symptoms they manifested observed, and post-mortem appearances noted."

Method. The animals were either placed in glass bell-jars of sufficient capacity for free respiration—and the jar covered and immersed in water of 115° F., later raised to 120° F.—or, held by the nape of the neck, they were directly immersed in the heated water.

Results. They exhibited the phenomena of sunstroke, and died. A hearty meal hastened fatality. The sequence of symptoms were restlessness, increased pulse, and respiratory rate, distention of blood-vessels, slight outcry, coma, primary dilatation of pupil, soon followed by its contraction. Upon contraction of the pupil, subjection to artificial heat was discontinued. Within a half-hour of the occurrence of pupil contraction, the bloodvessels cease to be distended, then cyanosis, slowing of the respiration, convulsions occasionally, and death follow. The animals directly immersed in water exhibited within five minutes rigid and permanent contraction of all muscles.

Autopsy, of immediate performance, discovered abdominal and thoracic temperatures not above 115° F., and either the heart ventricles firmly contracted, or permitted the observation of their contraction within ten minutes after death. The auricles were distended with blood and exhibited fibrillar movements. Neither brain nor lungs were congested. The venæ cavæ were engorged with dark alkaline blood rapidly coagulating. The cut heart ventricles were acid in reaction. The microscopical appearance of the blood was normal, but that of the heart fibres showed loss of striæ. In a few hours heart rigidity gave way to flaccidity. Putrefaction was soon manifest. Hence, the prompt autopsies made by Dr. Horatio Wood discovered heart contraction, in contrast to the flaccid hearts observed several hours after death by Dr. Pepper.

CLASS 2. "Those in which artificial respiration was practised as soon as the animal became comatose, or the pupil became contracted."

Results. Life was not thus prolonged even subsequent to tracheotomy.

CLASS 3. "Those in which blood heated to 120° F. was injected into the veins of the animal from which it had been drawn, or in which the blood of an animal perishing from the disease produced by heat was injected into the veins of an animal of the same species."

Results. No toxic symptoms ensued.

CLASS 4. "Those in which it was proved that the muscular system of an animal could be paralyzed by heat while its nervous system was left intact."

Method. "The reflex actions of animals apparently moribund from the effects of heat presented a decided contrast to those of narcotism, or exhaustion of the nervous system." In cold-blooded animals, on account of the sluggishness of their circulation, the heart is the last organ to be influenced by a heated liquid. When thrown into water of 115° F. all the muscles of a frog become rigid in a few minutes. In partial immersion only the part immersed is affected. After immersion and rigidity of long duration, not only do irritation of distinct nerve centres cause convulsions of the immersed parts, but irritation of nerves locally and equally exposed to the heat that has rendered the muscles of the part rigid will meet convulsive response.

Hence the nervous system is less sensitive to heat than the muscular.

CLASS 5. "Experiments on muscular contractility is affected by heat."

Results. The more violent the activity of muscles subjected to heat, the more promptly did they become rigid. While the cut surfaces of muscles made rigid by heat are decidedly acid, those of animals dying of other agencies (*e. g.*, section of medulla or toxic tetany) are not. The non-striated muscular fibre of arterioles of heat-stricken animals would not contract in response to cold or galvanism, but intestinal peristalsis was well marked. The normally contracted pupil of the dead frog dilated on immersion in water at 118° F.

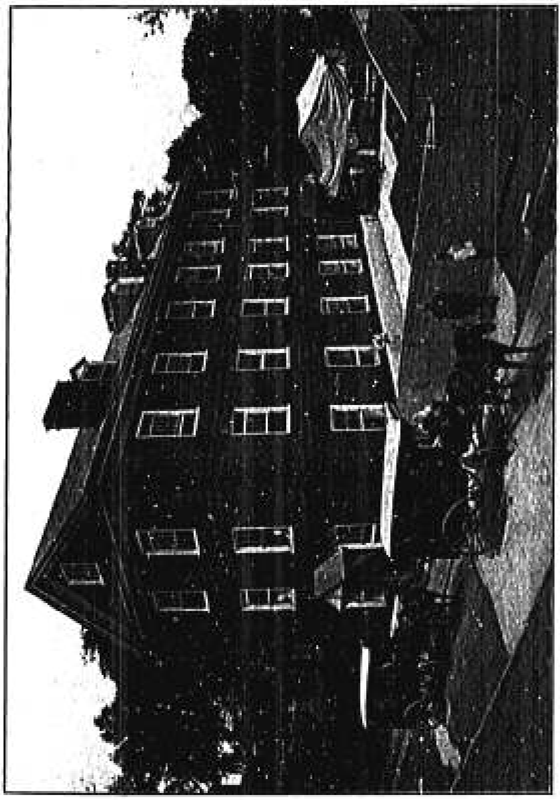
The experimental data of the paper was supplemented by clinical and post-mortem observations on man, and a presentation of existing theories of his own. Finally, in the recapitulation of his experimental results are the following notes:

"A temperature of the blood below 115° F. is sufficient to destroy life in all vertebrates, and causes phenomena similar to those of sunstroke, while a temperature between 115° F. and 120° F. is sufficient to cause rigid contraction and paralysis of the muscles whether connected with or separate from the body of the animal. The more violently a muscle is made to contract before subjection to heat the sooner it becomes paralyzed."

Dr. Dowler's observation of axillary temperature of 112° F. establishes that the temperature of the blood in sunstrokes is sufficient to produce paralysis. The dilatation of the capillaries is explicable by the direct effect of the heated blood upon the muscle fibres of the walls of the arteries and arterioles. The cerebral symptoms and the full and forcible pulse may be due to this dilatation.

"The effect of heated blood upon the heart is termed paralysis rather than exhaustion, because the heart has been shown to have the power of directly paralyzing its muscular tissue, and because in sunstroke the first stage, or that of frequent and forcible contraction of the heart, is not an essential part of the disease."

This paper not only confirmed the announcements of Bernard, although it does not allude to them, but it also contributed much new knowledge which later was largely corroborated by other observers, and doubtless helped to inspire their work.



Receiving ward (North House) and sunstroke tent, Pennsylvania Hospital.

In 1866 Dr. George B. Wood, visiting physician to the Pennsylvania Hospital, in the sixth edition of his *Practice of Medicine*, advocates the term *heat fever* in preference to the term *thermic fever*, suggested by Dr. Horatio C. Wood, and of which heat fever is but a translation. Either of these names Dr. George B. Wood prefers to insolation, etc., because the condition in mind though a consequence to heat is not one exclusively of solar heat.

In 1866 Dr. Levick, as he reports in 1868, treated 22 cases in one week at the hospital (see Graphic and Statistical Chart, in later publication). Of 12 cases treated by affusions and entire bath, 7 died. Of 7 rubbed with ice, 6 recovered; 2 of these had temperatures of 109° F. This is the first record of a recovery from such elevation of temperature, and it apparently marks the first fully intelligent application of cold in the treatment of heat fever. The earlier use of general ice frictions (p. 511) was to relieve the heat of the *skin*. The treatment by Dr. Levick of the cases occurring in 1866 must have been instanced by his appreciation of the indications of the newly discovered pathology of this disease, for general refrigeration of the blood, and, with equal propriety, it might be said of the muscular tissues, but that Dr. Levick in the paper next in order of review, refers only to that portion of the paper of Dr. Stiles that deals with the blood, and makes no allusion to his discoveries concerning the action of heat on muscle.

In 1868 Dr. Levick, in the *Pennsylvania Hospital Reports*, vol. i., p. 24, contributes a paper entitled, "Heat Fever (Sunstroke)," and credits the title of Dr. George B. Wood. No allusion is made to "thermic fever," a title of prior date, coined by Dr. Horatio C. Wood.

The paper begins and ends with emphasis on the fact that "two or more pathological conditions, very distinct in their phenomena if not in their nature, are often spoken of indiscriminately as insolation or sunstroke." It has two "obvious forms," and another, of which he says, "surely, it were an unnecessary refinement to give this disease a classification separate from meningitis." He, therefore, differentiates, and so clearly as to need no present modification, three forms of heat effect: 1. *Exhaustion from Heat.* 2. *Meningitis.* 3. *Heat Fever.* Dowler, in 1841, made the same classification with a different terminology, limiting the exciting cause to solar heat; whereas, Dr. Levick states specifically that either of these forms of heat effect may arise from solar or from artificial heat. He also refers to high humidity as a strong etiological factor in the production of pathological results from heat, and suggests that the mortality on the "Liverpool" in the Persian Gulf was possibly increased by keeping the decks wet (p. 491). Due credit is given the paper of Dr. Hunt.

A detailed clinical history, with notes of autopsy, of microscopical examination of the blood, and of a control experiment with, and examination of, the blood of a healthy individual, is followed by a claim for priority in noting the resemblances between the "phenomena of sunstroke and those of an idiopathic fever." The claim is supported by quotations from the essay on sunstroke in THE AMERICAN JOURNAL OF THE MEDICAL SCIENCES, 1859, p. 50, already noted and by a repetition of the parallel between the symptoms and post-mortem appearances of heat fever and of typhus fever as a type of the idiopathic fevers. The teachings at the Pennsylvania Hospital of Drs. Gerhard and Pepper that the "essential pathology of this disease (the major form of heat effect) was to be found in an altered condition of the blood" is cited. "It was but a step further to notice the resemblance of the phenomena to those of an idiopathic fever."

The microscopical examination of the blood is the third reported in this condition, being preceded by that of Dr. H. C. Wood and also by that of Dr. Stiles in his experimental work. The negative observations of Dr. Stiles are in agreement with those of Dr. Wood and of other investigators of the appearances of the blood in this condition. Dr. Levick stands alone in reporting crenation of the corpuscles. The control experiment was made at his request by Dr. Roland G. Curtin, of the Philadelphia Hospital. Of four ounces of blood taken from a healthy woman, and divided into two equal portions, one was microscopically normal and clotted in twelve minutes. The other was gradually heated in a sand bath until the blood reached a temperature of 120° F. "The second portion was gradually heated in a sand bath until the thermometer placed in it was at 120° F. Under the microscope, the red corpuscles were now found to be about half their usual size, shrivelled, and crenated. This blood coagulated in five minutes less time than the first portion did. So far then as this proves anything, it would seem to show that while the vitality of the corpuscles of the blood may be destroyed by heat alone, something more than this is required to destroy its property of coagulating, when drawn from the circulation.

In the *Essay* of 1859, p. 51, already quoted on this point (p. 510 of this review), Dr. Levick expressed his belief in a "poisoned condition of the blood." The following quotation, referring to this point, shows a modification of opinion: "Absence of toxic properties would seem to be established by the experiments of Dr. R. Cresson Stiles." . . . It is interesting to recall that Dr. Horatio C. Wood expressed the same belief in 1863, and, as already stated, recants it in 1872.

The question of change in theory in treatment indicating the application of cold was raised on page 511 in noting the cases occurring and treated in 1866. The following paragraph presents Dr. Levick's view on this subject:

"Of the *modus operandi* of ice in these cases, but little need be said. In all probability it acts by its refrigerating properties alone, and yet, when the instantaneous effect of a drop or two of water on the red corpuscle as seen under the microscope is recalled, the question will present itself, Can there be any endosmotic action of the water in these cases which is eagerly seized upon by the parched blood?"

This third paper of Dr. Levick is of epochal import, and marks the beginning of intelligent treatment of the conditions considered.

In 1868, in the second volume of the Hospital Reports, Dr. James Hutchinson publishes a paper upon the success of one-fourth grain, hypodermic doses, of morphine in the control of convulsions in four[1] cases of sunstroke treated at the hospital that year. The injections were suggested and given by Dr. Herbert Norris, resident physician.

In Period IV., 1841–1870, 164 cases of heat effect were received at the hospital, the mortality being forty-nine. In this epoch marked progress was made in the study and treatment of heat effects. The most notable events were the first use of ice-water affusions, by Markoe, and of ice applied to the head, as noted by Dowler, both in 1841; the publication by Dowler, in the same year, under a different terminology, of the classification recognized, but not published, by Condie in 1818; the further classification by Dowler of a meningitic type; the recording by Dowler, in 1845, of the first thermometric observation of hyperpyrexia (113° F.) in the major form of heat effect; the suggestion by Morehead, in 1856, that the pathology of the condition depended on the temperature of the blood being abnormally increased, and possibly acting directly on the heart; the first application by Darrach, in 1857, of treatment by general refrigerating friction with ice; the confirmation of Morehead's "suggestion" by the experimental work of Bernard in 1858–59 and by Stiles in 1864; the comparison of heat effects with fevers by Levick, in 1859; the discoveries of the last two observers of the effects of heat upon muscle and nerve; the negative microscopical examination of the blood by Wood, in 1863, and his denomination of the major form of heat effect as thermic fever; and, finally, the institution of an intelligent use of opium in the control of convulsions by Hutchinson and Norris, in 1868. The achievements of the period reviewed were but preparatory for further advances in the period 1841–1870, which will be presented in a later publication.

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[1] In four cases is this use of morphine recorded by Dr. Hutchinson—not sixteen, as stated on p. 110, by Dr. Horatio C. Wood, in Sunstroke.